J. Phys. Ther. Sci.
27: 273–277, 2015

Original Article

Effect of horseback riding versus a dynamic and static horse riding simulator on sitting ability of children with cerebral palsy: a randomized controlled trial

Peeraya Temcharoensuk[1)], Raweewan Lekskulchai[1)*], Chanut Akamanon[1)], Pattama Ritruechai[2)], Sureelak Sutcharitpongsa[3)]

[1)] *Faculty of Physical Therapy, Mahidol University: 999 Phuttamonthon 4 Road, Salaya, Nakhon Pathom 73170, Thailand*
[2)] *Faculty of Veterinary Science, Mahidol University, Thailand*
[3)] *Department of Pediatrics, Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand*

Abstract. [Purpose] A randomized controlled trial was conducted to investigate the immediate effects of horseback riding (HR) and a dynamic (DHS) and static (SHS) horse riding simulator (OSIM uGallop, Taiwan) on sitting ability of children with cerebral palsy. [Subjects and Methods] Thirty children with cerebral palsy were recruited and randomly assigned into three groups. Children received 30 minutes of exercise according to their assigned group. The Segmental Assessment of Trunk Control (SATCo) and Gross Motor Function Measure-66 (GMFM-66) sitting dimension were used to assess children in all groups both before and after the interventions. [Results] Sitting abilities were significantly improved after all interventions. Horseback riding showed the most improvement, followed by the dynamic and static horse riding simulator groups. Horseback riding also showed a significant improvement in the GMFM sitting dimension. [Conclusion] Horseback riding was the best intervention for promoting sitting ability of children with spastic cerebral palsy. However, a dynamic horse riding simulator can be a good surrogate for horseback riding when horseback riding is not available.
Key words: Cerebral palsy, Horseback riding, Horse riding simulator

(This article was submitted Jun. 25, 2014, and was accepted Aug. 24, 2014)

INTRODUCTION

Cerebral palsy (CP) is a common disorder that causes physical disability in children throughout life and begins in early childhood[1)]. More than half of children with CP have spasticity leading to difficulties in controlling posture and movements required for adequate hand function and learning[2)]. Horseback riding is a physical therapy intervention that aims to promote postural stability in children with CP[3–7)]. Previous studies have indicated therapeutic effects of horseback riding including improvement of postural stability[8)], increase of sensory inputs[9–11)], decrease of muscle tone[3, 12, 13)], increase of range of motion[14)], facilitation of muscle synergy[3, 15)], and improvement of postural muscle activities[7)]. Although the benefits have been widely reported, this intervention is often not available for most children due to limited access to horses, unpredictable weather, relatively high cost, and some children being reluctant to make contact with real horses. Therefore, the idea of a dynamic saddle that imitates the movement of a riding horse by producing three-dimensional movements similar to the horse walking pattern was suggested. Although the benefits of such a dynamic horse riding simulator for children with CP have been reported[12, 16–19)], studies that have compared its effect with that of horseback riding are scarce.

Assessment of subtle changes in sitting ability is required to monitor the effectiveness of assigned interventions. The Segmental Assessment of Trunk Control (SATCo) is an evaluative tool that examines sitting stability by means of level and type of trunk control[20)]. The SATCo was created based on the idea that upright trunk control involves functions from many biomechanical structures that develop in a progressive manner. Thus, the SATCo evaluates trunk control level by the levels of subunits, so called “functional segments”, including head, upper thoracic, mid-thoracic, lower thoracic, upper lumbar, lower lumbar, and full trunk control. Each subunit assesses three different aspects including static, active, and reactive control. According to Butler et al., the interrater reliability and validity of the SATCo showed high correlation with both the Alberta Infant Motor Scale (AIMS) and the Gross Motor Function Measure (GMFM) sitting dimension[20)]. Instruction of using SATCo

*Corresponding author. Raweewan Lekskulchai (E-mail: raweewan.lek@mahidol.ac.th)

Table 1. Demographic characteristics of the children in each group

Group	Number of children	Mean age ± SD (years)	Gender		GMFCS level	
			Boy	Girl	II	III
HR	10	10.7 ± 1.7	5	5	5	5
DHS	10	10.1 ± 1.7	4	6	5	5
SHS	10	10.4 ± 1.5	5	5	5	5
Total	30	10.4 ± 1.5	14	16	15	15

HR: horseback riding group, DHS: dynamic horse riding simulator group, SHS: static horse riding simulator group

has been published and no specific training was required. By using this test, specific changes in sitting ability could be monitored by means of segments and types of control. For assessing sitting ability by means of function, the Gross Motor Function Measure-66 (GMFM-66) sitting dimension is a standard measure generally used for clinical and research purposes. Various methods of using and interpreting the GMFM have been provided to support clinicians and researchers[21)].

In order to detect the true outcomes gained from the provided intervention without the interference of other factors, studies that focus on immediate therapeutic effects should be used[15, 22)]. Therefore, this study was conducted to compare the immediate effects of horseback riding (HR), a dynamic horse riding simulator (DHS), and a static horse riding simulator (SHS) on sitting ability of children with spastic CP using a randomized controlled trial. We hypothesized that HR would provide the best immediate effects compared with the other two interventions; however, the imitated movements of a horse provided by the DHS should at least provide better benefits than just sitting astride as in the case of the SHS.

SUBJECTS AND METHODS

Thirty children, a sample size of 10 per group, were recruited from a rehabilitation center. The inclusion criteria were 1) diagnosis of the bilateral spastic type of CP, 2) classification according to Gross Motor Function Classification system (GMFCS) within levels II–III, and 3) no participation in any horse riding session within 1 year prior to the study (Table 1). The exclusion criteria were children with congenital anomalies and cognitive problems. A full explanation of the procedures was provided, and informed consent was obtained from the parents or caregivers. This study was approved by the human research ethics committee of Mahidol University.

One researcher was responsible for group assignment, assessment, and intervention in every group. The participants, divided into three groups using stratified randomization by GMFCS level, were assigned by drawing lots. Then, each child was pre-assessed with regard to sitting ability by using the SATCo and GMFM-66 sitting dimension, respectively.

After pre-assessment, each child received an intervention according to his/her group assignment. For the HR group, training was conducted by staff of the Faculty of Veterinary Science, Mahidol University, who had experience in providing training for HR to children with special needs. Three staff members including one who led the horse at a walk and two who walked at the horse' side ensured that the protocol was followed and that it was safe, but they did not provide postural support to the child at any moment. The children were placed on a saddle. They were instructed to hold a handle that was provided, and they always wore a helmet while riding. The horse was led at a walk around an arena in the clockwise and counterclockwise directions. The children were asked to actively adjust their postures. The total horse riding time was 30 minutes. For the DHS group, the riding intervention was administered with a mechanical horse riding simulator (OSIM uGallop, Taiwan). A monitor playing an animated movie was placed in front of the machine to encourage the child's attention throughout the riding session. The children were asked to sit astride comfortably on a saddle and to hold onto a handle, and then the machine was turned on. The speed of the machine was set at speed 1, which was approximately 60 cycles/minute. The children were asked to actively adjust their postures. The training interval was 30 minutes. The examiner and caregiver stood on either side of the child for safety throughout the riding session. For the SHS group, the environment and setting were similar to those for the DHS group except that the horse riding simulator was powered off throughout the training period. The examiner and caregiver also accompanied the child in the same positions as described for the DHS. The children were asked to sit astride the saddle and place their hands on a handle while focusing on the monitor in front of them for 30 minutes.

After the intervention, the children in each group were reassessed within 10 minutes. Both pre- and post-assessment data were collected by a pediatric physical therapist who had more than 10 years of working experience and was blinded to the group assignments. For the SATCo assessment, the number of controlled segments for each type of control was determined for three sitting ability outcomes including the static control score, active control score, and reactive control score. For the GMFM assessment, the sitting dimension scores were transferred to the WINSTEP software to convert the outcomes into a continuous scale using Rasch analysis[23)]. The final GMFM outcome was called the sitting ability score.

The statistical analyses were performed using SPSS for Windows. A p-value of less than 0.05 was considered statistically significant. Since the SATCo data were not distributed normally, the Wilcoxon signed-rank test and Kruskal-Wallis test were used for comparing variables between before and

Table 2. Pre- and post-intervention GMFM sitting ability scores (mean±SD)

	HR (n=10)	DHS (n=10)	SHS (n=10)
Pre-intervention score	71.5±12.1	64.7±20.8	66.7±10.6
Post-intervention score	106.2±19.8*	73.6±18.9	74.4±7.6

HR: horseback riding group, DHS: dynamic horse riding simulator group, SHS: static horse riding simulator group. *: significant difference among the groups ($p<0.05$)

after the intervention and among the three interventions, respectively. The Mann-Whitney U test was applied for multiple comparisons of different pairs of SATCo variables among groups. For the GMFM sitting ability score, analysis of variance (ANOVA) was used for comparing changes across time and among groups.

RESULTS

For the SATCo data, one child in the DHS group was excluded due to being fatigued and noncooperative. Therefore, the total number of participants for the SATCo assessment was 29. The within-group analysis for SATCo revealed significant differences between pre- and post-intervention SATCo scores in all groups: the HR group showed significant differences in static ($p=0.038$), active ($p=0.026$), and reactive control ($p=0.006$) scores; the DHS group showed differences in active ($p=0.034$) and reactive control ($p=0.034$) scores; and the SHS group showed differences only in the active control score ($p=0.046$). The between-group analysis of SATCo scores was performed by subtracting the pre-intervention score from the post-intervention score in each type of control. Only the reactive control score was significantly different among the 3 groups ($p<0.05$). The results of the Mann-Whitney U test with Bonferroni adjustment at $p<0.0167$ indicated that the reactive control score of the HR group was different from that of the SHS group ($p=0.004$). No significant differences were found between the HR and DHS groups or between the DHS and SHS groups.

There were no significant differences in the pre-intervention GMFM sitting ability scores among the groups. However, the post-intervention scores revealed significant differences ($F (2, 29)=12.75$, $r= 0.70$, $p<0.001$) (Table 2). Tukey HSD multiple comparisons of sitting ability scores found significant differences between the HR and DHS groups (95% CI = 14.34–50.86, $p<0.001$) and between the HR and SHS groups (95% CI = 13.53–50.05, $p=0.0001$).

DISCUSSION

This study provided three stimuli to the children including 1) an astride sitting posture (for the HR, DHS, and SHS groups), 2) machine or horse movements (for the DHS and HR groups), and 3) the direct contact with a real animal (for the HR group).

Regarding sitting ability as measured by the SATCo, the children who received all three stimuli (HR) showed improvements in static, active, and reactive control in sitting positions. The children in the DHS group, who received no contact with real horses, showed improvements in active and reactive control, whereas the children who received only the astride sitting posture showed improvements in active control in sitting. When comparing the groups, we found that the children in the HR group improved their reactive sitting control the most, and this improvement was different from the improvement found in the SHS group. The improvement of reactive control in the HR group was not different from that in the DHS group. These results indicate that the reactive sitting control of children with spastic CP could be improved through astride sitting on a moving saddle (DHS) or a real horse (HR). In addition, sitting astride on a static saddle could improve active control in the sitting position. Sitting astride a saddle could stretch the muscles of the lower extremities, especially the adductor group, which always shows high muscle tension in children with spastic CP. Prolonged stretching, e.g., 30 minutes, of lower extremity muscles can result in decreasing spasticity[24], and as a consequence, an improvement in joint range of motion (ROM) can be observed[12, 14]. Moreover, as a protective mechanism while sitting on a horse or a mechanical horse riding simulator, children develop a strategy to prevent falling off and for maintenance of their postures; therefore, body awareness in space is continuously facilitated. In order to maintain their center of gravity (COG) within the base of support while riding, children have to anticipate and compensate for their postural adjustments by reducing COG displacement to remain safely on a moving surface. By shifting their body weight in response to rhythmic movement, multiple sensory inputs and efferent motor outputs from the CNS are constantly stimulated throughout a riding session in order to secure balance and posture, eventually leading to an improvement in postural stability, equilibrium reaction, and correction of upright alignment[8, 16, 18, 25, 26]. These explanations therefore support the improvement of active and reactive sitting control in the present study. For static sitting control, the outcomes revealed that only the HR group showed significant changes in static control. The experience of being in direct contact with a horse may play an important role in improving static trunk control.

Regarding assessment of sitting ability by means of function, the pre-intervention GMFM score did not differ between groups. After training, the GMFM sitting ability of children in the HR group showed the most improvements and was significantly different from those of the DHS and SHS groups. These outcomes are in agreement with previous research demonstrating that horse riding provides benefits with respect to gross motor ability[7, 27]; however, the present study also shows that these benefits are greater than those derived using only a dynamic or static horse riding simulator.

When comparing the HR and DHS results, one possible reason for the superiority of HR, rather than just the use of a real animal, is the different quantity of sensory system stimulation. In HR, the horse was led at a walk in several directions, such as straight forward and turning left or right, and with different movement types such as unsteady speed and walking patterns. The variety in horse direction and movement are believed to induce more signals from proprioceptive and vestibular receptors through various postural challenges. Although a mechanical simulator can produce three-dimensional movement that mimic a horse walking[25, 26], it cannot create the variety of movements of a riding horse in its pre-set programs. In other words, a mechanical simulator creates a steady speed and repeated movements similar to those of a horse walking straight ahead, but it does not produce any directional challenge. Therefore, it creates the same postural challenge for the rider at all times. In the DHS and SHS groups, improvements were found, but they were not comparable with those of the HR group. The improvements in sitting function in these two groups may have been due to decreasing the spasticity of the muscles around the pelvic and hip joints, which consequently increased the pelvic ROM. In a study by Quint and Toomey (1998) in which the pelvic angles of children with CP who received mechanical saddle and static saddle training were compared, an improvement in tilted angles was found in both groups, but it was more prominent in the mechanical saddle group[12]. A static saddle also improves trunk extension, as reported in study by Reid[28]. The DHS group differed from the SHS group, as it was exposed to a 3-dimensional rhythmical movement of the saddle. Therefore, we would have expected that aside the positive effects seen in the SHS group, there should have been a further positive effect from the constant rhythmic facilitation. However, this was not found in this study, and this might be due to the limited training duration we used, as the immediate effects of the training were explored after just a 30-minute session. In order to improve motor performance and sustain the improvement, learning and practicing are key. Compared with the DHS, the positive effect of muscle relaxation was not prolonged in the SHS group, and the sensory inputs and motor outputs were not as highly stimulated as in the DHS group. Therefore, further examination of the long-term effect of both training interventions is recommended for detection of possible distinct performances.

As our primary objective was to explore immediate changes, an uncomplicated assessment tool that would not require long duration of settings with a standardized measure was important. Assessment of biomechanical changes, though give more specific details, requires long duration to manipulate and it is not conveniently moveable. The assessment tools selected in this study were standardized measurements. Although our method cannot give in-depth quantitative details concerning how muscles activate or how the pattern of the COG changes in response to an intervention, it provides sufficient functional outcomes to compare alterations across time. The homogeneity of the children who participated in this study may be both a strong and weak point. A strong point of the recruited participants is that they all had the spastic diplegic type of CP, and thus no variations in the type of CP interfered with the results of this study[29–31]. However, this can also be considered a limitation, as the results of this study can be interpreted with respect to only children with spastic diplegic CP and more specifically those classified as GMFCS levels II-III. Herrero et al. found that children with less severe CP can benefit from training more than children with more severe CP[19]. Therefore, future studies should compare the effect of horseback riding and horse riding simulators on other types and severity levels of CP.

In conclusion, this study indicates high positive benefits of HR in children with CP. Therefore, whenever possible, we recommended HR as the best intervention choice. However, if the availability of horses is a problem, a DHS may be a good surrogate for horse riding. Although the results showed that DHS was less beneficial than HR, it is believed that combining DHS with the cooperation to increase somatosensory stimulation would induce various HR-like effects. Examples of this in DHS training are setting various speeds of the machine randomly, and motivating children to perform action-inducing multiple directional challenge.

ACKNOWLEDGEMENTS

The authors sincerely thank Mrs. Kanjana Thipsook and the staff of the rehabilitation center for their hospitality and Dr. Norberto Asensio for reviewing this manuscript.

REFERENCES

1) Rosenbaum P: Cerebral palsy: what parents and doctors want to know. BMJ, 2003, 326: 970–974. [Medline] [CrossRef]
2) Rosenbaum P, Paneth N, Leviton A, et al.: A report: the definition and classification of cerebral palsy April 2006. Dev Med Child Neurol Suppl, 2007, 109: 8–14. [Medline]
3) Benda W, McGibbon NH, Grant KL: Improvements in muscle symmetry in children with cerebral palsy after equine-assisted therapy (hippotherapy). J Altern Complement Med, 2003, 9: 817–825. [Medline] [CrossRef]
4) Murphy D, Kahn-D'Angelo L, Gleason J: The effect of hippotherapy on functional outcomes for children with disabilities: a pilot study. Pediatr Phys Ther, 2008, 20: 264–270. [Medline] [CrossRef]
5) Pauw J: Therapeutic horseback riding studies: problems experienced by researchers. Physiotherapy, 2000, 86: 523–527. [CrossRef]
6) Sterba JA: Does horseback riding therapy or therapist-directed hippotherapy rehabilitate children with cerebral palsy? Dev Med Child Neurol, 2007, 49: 68–73. [Medline] [CrossRef]
7) Sterba JA, Rogers BT, France AP, et al.: Horseback riding in children with cerebral palsy: effect on gross motor function. Dev Med Child Neurol, 2002, 44: 301–308. [Medline] [CrossRef]
8) Shurtleff TL, Standeven JW, Engsberg JR: Changes in dynamic trunk/head stability and functional reach after hippotherapy. Arch Phys Med Rehabil, 2009, 90: 1185–1195. [Medline] [CrossRef]
9) Forssberg H, Hirschfeld H: Postural adjustments in sitting humans following external perturbations: muscle activity and kinematics. Exp Brain Res, 1994, 97: 515–527. [Medline] [CrossRef]
10) Hirschfeld H, Forssberg H: Epigenetic development of postural responses for sitting during infancy. Exp Brain Res, 1994, 97: 528–540. [Medline] [CrossRef]
11) Hammer A, Nilsagård Y, Forsberg A, et al.: Evaluation of therapeutic riding (Sweden)/hippotherapy (United States). A single-subject experimental design study replicated in eleven patients with multiple sclerosis. Physiother Theory Pract, 2005, 21: 51–77. [Medline] [CrossRef]
12) Quint C, Toomey M: Powered saddle and pelvic mobility: an investigation into the effects on pelvic mobility of children with cerebral palsy of a powered saddle which imitates the movements of a walking horse. Physiotherapy, 1998, 84: 376–384. [CrossRef]
13) Bertoti DB: Effect of therapeutic horseback riding on posture in children with cerebral palsy. Phys Ther, 1988, 68: 1505–1512. [Medline]
14) Encheff JL, Armstrong C, Masterson M, et al.: Hippotherapy effects on trunk, pelvic, and hip motion during ambulation in children with neurological impairments. Pediatr Phys Ther, 2012, 24: 242–250. [Medline]

[CrossRef]
15) McGibbon NH, Benda W, Duncan BR, et al.: Immediate and long-term effects of hippotherapy on symmetry of adductor muscle activity and functional ability in children with spastic cerebral palsy. Arch Phys Med Rehabil, 2009, 90: 966–974. [Medline] [CrossRef]
16) Kuczyński M, Słonka K: Influence of artificial saddle riding on postural stability in children with cerebral palsy. Gait Posture, 1999, 10: 154–160. [Medline] [CrossRef]
17) Fernandes LC, Chitra J, Metgud D, et al.: Effectiveness of artificial horse riding on postural control in spastic diplegics − rct. IJPOT, 2008, 2: 36–40.
18) Silva e Borges MB, Werneck MJ, da Silva ML, et al.: Therapeutic effects of a horse riding simulator in children with cerebral palsy. Arq Neuropsiquiatr, 2011, 69: 799–804. [Medline] [CrossRef]
19) Herrero P, Gómez-Trullén EM, Asensio A, et al.: Study of the therapeutic effects of a hippotherapy simulator in children with cerebral palsy: a stratified single-blind randomized controlled trial. Clin Rehabil, 2012, 26: 1105–1113. [Medline] [CrossRef]
20) Butler PB, Saavedra S, Sofranac M, et al.: Refinement, reliability, and validity of the segmental assessment of trunk control. Pediatr Phys Ther, 2010, 22: 246–257. [Medline] [CrossRef]
21) Brunton LK, Bartlett DJ: Validity and reliability of two abbreviated versions of the Gross Motor Function Measure. Phys Ther, 2011, 91: 577–588. [Medline] [CrossRef]
22) McGee MC, Reese NB: Immediate effects of a hippotherapy session on gait parameters in children with spastic cerebral palsy. Pediatr Phys Ther, 2009, 21: 212–218. [Medline] [CrossRef]
23) Linacre JM: A User's Guide to Winsteps Rasch-Model Computer Program. Chicago: MESA Press, 2002.
24) Pin T, Dyke P, Chan M: The effectiveness of passive stretching in children with cerebral palsy. Dev Med Child Neurol, 2006, 48: 855–862. [Medline] [CrossRef]
25) Kitagawa T, Takeuchi T, Shinomiya Y, et al.: Cause of active motor function by passive movement. J Phys Ther Sci, 2001, 13: 167–172. [CrossRef]
26) Mitani Y, Doi K, Yano T, et al.: Effect of exercise using a horse-riding simulator on physical ability of frail seniors. J Phys Ther Sci, 2008, 20: 177–183. [CrossRef]
27) Whalen CN, Case-Smith J: Therapeutic effects of horseback riding therapy on gross motor function in children with cerebral palsy: a systematic review. Phys Occup Ther Pediatr, 2012, 32: 229–242. [Medline] [CrossRef]
28) Reid DT: The effects of the saddle seat on seated postural control and upper-extremity movement in children with cerebral palsy. Dev Med Child Neurol, 1996, 38: 805–815. [Medline] [CrossRef]
29) Bigongiari A, de Andrade e Souza F, Franciulli PM, et al.: Anticipatory and compensatory postural adjustments in sitting in children with cerebral palsy. Hum Mov Sci, 2011, 30: 648–657. [Medline] [CrossRef]
30) Brogren E, Hadders-Algra M, Forssberg H: Postural control in sitting children with cerebral palsy. Neurosci Biobehav Rev, 1998, 22: 591–596. [Medline] [CrossRef]
31) Girolami GL, Shiratori T, Aruin AS: Anticipatory postural adjustments in children with hemiplegia and diplegia. J Electromyogr Kinesiol, 2011, 21: 988–997. [Medline] [CrossRef]